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Making personalised nutrition the easy choice: creating policies to break down the barriers and reap the benefits

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Highlights

Personalised nutrition (PN) has the potential to reduce incidence of disease and reduce health costs;

Food4Me data are reported with implications for European and national policy to widen access to PN;

Both public and private personalised nutrition delivery systems are needed;

Policies are required to approve and regulate providers to ensure that data are handled

securely;

Personalised dietary plans need put into place in workplaces, retail and catering outlets.

Making personalised nutrition the easy choice: creating policies to break down the barriers and reap the benefits

Personalised diets based on people's existing food choices, and/or phenotypic information, and/or genetic data hold potential to improve public dietary health. The aim of this analysis, therefore, has been to examine the degree to which factors determining uptake of personalised nutrition vary by EU country to better target of policies to encourage uptake, and optimise the health benefits of personalised nutrition technology. A questionnaire developed from previous qualitative research was used to survey nationally representative samples from 9 EU countries (N=9381). Perceived barriers to the uptake of personalised nutrition comprised three factors (data protection, the eating context, societal acceptance). Trust in sources of information comprised 4 factors (commerce and media, practitioners, government, family and friends). Benefits comprised a single factor. Analysis of Variance (ANOVA) was employed to compare differences in responses between the United Kingdom; Ireland; Portugal; Poland; Norway; the Netherlands; Germany; and Spain. The results indicated that those in Greece, Poland, Ireland, Portugal and Spain, rated the benefits of personalised nutrition highest, suggesting a particular readiness in these countries to adopt personalised nutrition interventions. Greek participants were more likely to perceive the social context of eating as a barrier to adoption of personalised nutrition, implying a need for support in negotiating social situations whilst on a prescribed diet. Those in Spain, Germany, Portugal and Poland scored highest on perceived risk/barriers related to data protection. Government was more trusted than commerce to deliver and provide information on personalised nutrition overall. This was particularly the case in Ireland, Portugal and Greece, indicating an imperative to build trust, particularly in the ability of commercial service providers to deliver personalised dietary regimes effectively in these countries.

Key words: Survey; Personalised Nutrition; Nutrigenomics; Attitudes; Europe; Food4Me.

1. Introduction

Public health challenges currently facing Europe (EU) include the need to reduce rates of obesity, as well as the incidence of non-communicable dietary related diseases such as type-2 diabetes, cardiovascular disease and certain cancers (EC, 2014). This challenge is complicated by unequal distribution of these conditions across societal groups and European countries (Divajeva1 et al., 2014). In recent years, the gap in health outcomes has widened between the highest and the lowest social strata within the EU (UCL Institute of Health Equity, 2013) and such inequalities are likely to increase further as the economic crisis continues (Stuckler et al., 2010). Current thinking emphasises prevention rather than treatment in addressing these public health problems, whilst at the same time it has been recognised that there is a need to widen access to supporting health services (Wilson and Langford, 2014; EC, 2014). Initiatives such as personalised nutrition, which are directed toward reversing rising trends in non-communicable diseases, should go some way toward reducing such health inequalities. Individualised or personalised health promoting interventions have been shown to be particularly successful in bringing about healthy behaviour change in as many as one third of users (de Bourdeaudhuij & Brug, 2000; Egglestone et al., 2013; Elder et al., 2009; Webb et al., 2010). Digital technological advance is expected to revolutionise preventative public health care (EC, 2014) by enabling an individualised approach to health that would be cost effective and, if made available to all, could go some way toward addressing cross-national and socio-economic inequalities in health (Wilson and Langford, 2014; EC, 2014).

Personalised nutrition is one such approach, according to which personalised diets are delivered based on people's existing diets and/or phenotypic information and/or genetic data (Celis-Morales et al, 2015; Ferguson et al, 2014). If rolled out to the general population, personalised

nutrition offers a means by which to address challenges and inequalities related to the prevention and management of obesity and non-communicable disease (Brug, et al., 1999). In effect, personalised nutrition has the potential to meet at least six out of the ten public health policy objectives outlined by the European Commission: prevention of disease; encouragement of healthier lifestyles; enhancement of well-being; improved access to health care; promotion of health information; and support of dynamic health systems and new technologies (EC., 2014). Previous research has suggested that these are also the types of benefits perceived to be important among the general public (Morin, 2009; Poínhos et al., 2014; Stewart-Knox et al., 2013; Su and Lu, 2012). Personalised nutrition, if adopted widely, could reduce health care costs by as much as 13% (Marsh and McLennan, 2014). The European Commission (EC), therefore, aims to make personalised diets widely accessible by 2050 (Bock et al., 2014).

Whereas only a few studies have focused on attitudes towards personalised nutrition (table 1), a corpus of research has examined attitudes toward genetic testing in the context of personalised medicine (Gibney & Walsh, 2013). Qualitative and survey studies undertaken within Europe and beyond have indicated positive attitudes towards genetic testing, suggesting that this aspect of the technology is unlikely to pose a problem in rolling out personalised nutrition services (for a review see Stewart-Knox et al., 2014). Genetic testing, however, would constitute only the most „medicalised" aspect of personalised nutrition. Existing research into genetic testing, therefore, has only limited relevance to personalised nutrition which represents a more holistic concept, which may or may not involve genetic testing. Personalised nutrition, in contrast, considers an array of personal, lifestyle, dietary, phenotypic and genetic data which may be interpreted back to the individual along with a personalised prescription for action (e.g. Food4me.org).

Qualitative research conducted as part of the Food4Me project (Rankin, 2015) has indicated that individuals perceived the direct-to-consumer (D-T-C) approach to personalised dietary health promotion in a way that was consistent with existing theories of behavioural change and, in particular, Social Cognitive Theory (SCT) (Bandura, 1989). In keeping with SCT, personalised nutrition, especially when made available D-T-C, puts control firmly in the hands of the individual (consumer/client/patient, etc.) enabling them to become active in goal setting, providing data, assimilating feedback and monitoring progress. Previous research has suggested that Europeans would welcome the freedom of choice and degree of control over their health that such an approach would afford (Ronteltap et al., 2009). This has been corroborated by survey research conducted as part of the Food4Me project, which has indicated that high Internal Health Locus of Control (Internal HLoC) (i.e. where health is in control of the individual) and Nutrition Self-Efficacy (NSE) (i.e. one's beliefs in capabilities to perform a desired task) both constitute major drivers of intention to adopt personalised nutrition (Poínhos et al., 2014). Those who had volunteered to take part in the Food4Me proof of principle study tended to have higher levels of NSE and internal HLoC compared to the general population survey participants (Panzone et al., under review). This congruence with theories of behaviours change should render personalised approaches to dietary health promotion particularly effective in bringing about compliance with prescribed diets, and in supporting the individual in the endeavour to manage their dietary-related health behaviour. For tailored health innovations to be sustainable, however, policies will need to be put in place that will enable people to manage their own health (Wilson and Langford, 2014). For health promoting initiatives to be effective, the target population should be treated as partners in the design and delivery of support services (Wilson and Langford, 2014). Taking this perspective, the Food4Me project has explored the views of the European public across 9 countries (Spain, the UK, Ireland, the Netherlands, Poland, Portugal, Norway, Greece and Germany) to gain an understanding of what would constitute best practice for the effective delivery of personalised nutrition.

Qualitative (Berezowska et al., 2014; Stewart-Knox et al., 2014; and, 2013) and survey (Poínhos et al., 2014) research conducted in Europe as part of the Food4Me project has suggested that the EU public hold, in general, positive attitudes toward personalised nutrition. This aligns with previous survey studies of public attitudes toward personalised nutrition (Roosen et al., 2008; Stewart-Knox et al., 2009; Su and Lu, 2012) which have indicated that between one third and half of Europeans would be keen to take advantage of personalised nutrition. Among the benefits of personalised nutrition anticipated among the Food4Me study participants were increased fitness, time saving and convenience as well as benefits to other family members (Stewart-Knox et al., 2014; and, 2013). The European public, however, also perceived risks to be inherent in the on-line delivery systems that would provide personalised nutrition services, such as data mishandling and commercial exploitation of data (Poínhos et al., 2014; Stewart-Knox et al., 2014; and, 2013). Similarly, previous qualitative (Morin, 2000) and survey (Roosen et al., 2008) research has highlighted concerns around data security. Primary analysis of the Food4Me survey results has suggested that the latter may not be a barrier to adoption. The extent to which an individual perceived the benefits associated with the intention to adopt personalised nutrition directly predicted intention to adopt it. Perceived risks were indirectly associated with attitudes and intention to take up such services (Poínhos et al., 2014).

Another barrier highlighted by the Food4Me study was the difficulty perceived in adhering to a personalised dietary plan in social situations, in particular when eating outside the home (Stewart-Knox, 2013). This is in keeping with the findings of the EU-funded HECTOR project (2011) which indicated that foods eaten outside the home tended to be less healthy than those consumed within the home. Broader policies, therefore, may be required to encourage local catering outlets to provide healthy fast food options and to cater for personalised diets.

Contrasting views on whether public or private institutions would be most trusted to deliver on personalised nutrition were identified in the Food4Me qualitative study. Some

preferred personalised nutrition to be delivered as part of existing health services, while others favoured the anonymity and convenience afforded by commercial offerings (Berezowska et al., 2014; Fallaize et al., 2015; Stewart-Knox et al., 2014; 2013). This finding was novel given that previous studies have unanimously implied that the public would prefer services to be delivered through existing health provision (Pavlidis et al., 2012; Su and Lu, 2012; Wendel et al., 2013). The Food4Me survey confirmed that a large proportion of Europeans preferred health service provision, but also identified a second potential market comprised of those who preferred the anonymity and degree of control that D-T-C personalised nutrition would afford (Food4Me White Paper, 2015). This could imply a dual market for personalised nutrition as well as a need to tailor the delivery support system to differing needs. It is conceivable that in some cases D-T-C services could provide added value, for example, by delivering meals directly to the individual's home.

Existing research, including that which has been conducted as part of the Food4Me study, has established that Europeans hold positive views on personalised nutrition and are open to the concept of D-T-C personalised nutrition services (table 1). That the European public appear amenable to personalised nutritional health technologies bodes well for public health impact, provided that policies are put in place to render such a system available, effective and sustainable. For policy to be effective in addressing a problem, however, it has to be defined locally (Goldstein, 2009). Having established the factors determining and deterring the uptake of personalised nutrition, this analysis explores the distribution of these factors across the different EU countries, using data from the Food4me survey sample. The perceived benefits of personalised nutrition, perceived risks/barriers to the uptake of personalised nutrition, trust in the various agencies to provide personalised information and preferences for the provision of such services, have been explored cross-nationally with a view to determining how such issues could be addressed via policy.

Insert table 1 here

2. Methods

2.1. Sampling and Procedure

Ethical approval was granted by each of the lead academic organisations. Volunteers aged 18+ years were recruited from a market research agency panel (GfK-NOP) in 9 European countries (Germany, Greece, Ireland, Poland, Portugal, Spain, the Netherlands, the UK, and Norway). Recruits were quota sampled to be nationally representative (n>1000) for each country in terms of sex, age and level of education (see Poínhos et al., 2014 for a full account) Having obtained informed consent, the survey was administered on-line (N=9381) during February and March 2013. The operational definition of personalised nutrition was: "healthy eating advice that is tailored to suit an individual based on their own personal health status, diet, physical activity and/or genetics." The response rate was 31.9 %.

2.2. The Questionnaire

For a full account of how the questionnaire was designed see Poínhos et al. (2014). Perceived risk/barriers to the uptake of personalised nutrition were assessed using 18 items (see table 2) for which responses were measured on a 5-point Likert scale ranging from 1 = „Completely disagree" to 5 = „Completely agree" and which showed high reliability (α= 0.905). Trust in agencies to provide personalised dietary information was assessed using 14 items (see table 3) for which responses were measured on a 5-point Likert scale ranging from 1 = „Trust extremely" to 5 = „Distrust extremely" and which showed high reliability (α = 0.877). Perceived benefits of personalised nutrition were assessed using 9 items (see table 4) for which responses were on a 5-point Likert scale ranging from 1 = „Not increase it at all" to 5 = „Increase it extremely" and which showed high reliability (α= 0.938). Preferences for providers of personalised nutrition were assessed using the question: „Please indicate the extent to which you would prefer the following people or organisations to provide a personalised nutrition service - your family doctor/GP; private health care providers;

dieticians/nutritionists; or, supermarkets". Responses were measured on a 5-point Likert scale ranging from 1 = „Not at All" to 5 = „Extremely".

2.3. Data Analysis

Exploratory factor analysis using Bartlett's method was used to test the adequacy of the procedure and to check the factor structure of perceived benefits and barriers/risks to the uptake of personalised nutrition (on-line interface; eating context), and trust in agencies to convey information on personalised nutrition (commerce/media; professionals; government; friends/family). The extraction method was principal component analysis. The barriers/risks and trust factors then underwent Varimax rotation with Kaiser normalisation. Items with a loading magnitude greater than 0.50, and factors with an eigenvalue greater than 1, were included. Three factors together explained 69.2 % of the variance in barriers/risks: data protection (32%); eating context (23%); and societal acceptance (13%). All 18 items were accounted for in the analysis and there was no cross loading (table 2). Four factors together explained 67.0 % of the variance of trust in agencies to provide information on personalised nutrition: commerce/media (38.9 %); professionals (12.6 %); government (8.1 %); and, friends/family (7.5 %) (table 3). One factor explained 67.4 % of the variance and was described as perceived benefit. Of the 10 items, 9 loaded heavily onto this factor (table 4). The mean and standard deviation (SD) scores were computed for each of the 4 items enquiring about preferences for providers of personalised nutrition.

One-way, between-groups ANOVA were conducted to compare between country differences in the 3 factors representing responses to items on perceived barriers/risks, the 4 factors representing trust in service agencies, the single factor related to benefits of personalised nutrition, and the mean (SD) of the 4 items assessing preferences for who should deliver personalised nutrition. Statistical analysis was conducted using SPSS (Version 21.0; SPSS UK Ltd; Chersey, UK), and MPlus (Version 7.2). P values < 0.05 were considered significant.

Insert tables 2-4 here

3. Results

3.1. Sample Description

The chi-square goodness-of-fit test showed that the countries were similar in gender composition (χ^2= 4.51, df=8, p=0.808) with males accounting for 50.6% of the sample. The modal age-group, both for the total sample as well as within country was 40-54 years (34.8%). Modal education level for the whole sample was "middle" (38.9%). This was similar across the countries apart from the UK where the modal education level was "low" (49%) and the Netherlands where there was an equal number in the "middle" (35.6%) and "high" (35.6%) education levels.

3.2. Perceived Barriers/Risks to the Uptake of Personalised Nutrition

One-way ANOVA indicated significant differences between countries on all three factors: F1 – data protection (F=28.27; df=8; p<0.05); F2 – the eating context (F=38.52; df=8; p<0.05); and, F3 – societal acceptance (F=17.15; df=8; p<0.05). Those in Spain rated barriers/risks related to data protection significantly higher than any of the other countries (table 5a). A homogenous sub-set comprised of Norway, Ireland, Netherlands and UK gave significantly lower ratings compared to the other countries on barriers/risks related to data protection. Those in Poland rated barriers/risks related to the eating context (social) significantly higher, while the Netherlands rated them lower, than any other country. The other countries formed a homogenous sub-set on the eating context variable.

Insert table 5a and table 5b here

3.3. Trust in Agencies to Provide Information on Personalised Nutrition

There were significant differences between factors across countries in terms of trust in agencies to provide information on personalised nutrition: F1 - commerce/media ($F=25.59$; $df=8$; $p<0.05$); F2 - professionals ($F=7.64$; $df=8$; $p<0.05$); F3 - government ($F=28.25$; $df=8$; $p<0.05$); F4 - friends/family ($F=30.90$; $df=8$; $p<0.05$). Greek participants rated trust in commerce and the media to provide information on personalised nutrition significantly lower than any other country (table 6). Participants in Spain, the Netherlands and Portugal formed a homogenous subset with a significantly higher trust in commerce and the media than other countries. The UK participants rated trust in professionals to provide information on personalised nutrition significantly lower than any other country. Greek and Irish participants formed a homogenous subset that indicated significantly higher trust in professionals than other countries. Participants in the Netherlands, Greece and Poland comprised a homogenous subset that indicated significantly lower trust in government to provide information on personalised nutrition. Spanish participants indicated significantly higher trust in government agencies than any other country. Norwegian participants indicated significantly lower trust in friends and family to provide information on personalised nutrition compared to all other countries. There was a homogenous subset comprised of participants from the UK, Ireland, Germany and Poland, which indicated significantly higher trust in friends and family than other countries.

Insert table 6 here

3.4. Perceived Benefits of Personalised Nutrition

Significant differences were observed between countries in terms of perceived benefits ($F=138.75$; $df=8$; $p<0.05$). Those in Greece rated the benefits of personalised nutrition significantly higher than any other country (table 7). There was a homogenous subset comprised of Polish, Irish, Portuguese and Spanish participants which rated the benefits of personalised nutrition higher. Another homogenous subset comprised participants in the

Netherlands, UK, Norway and Germany, that rated the benefits of personalised nutrition significantly lower than participants in other countries.

Insert table 7 here

3.5. Preferences for Providers of Personalised Nutrition

There were between-country differences in preferences for family doctors/GP ($F=34.79$; $df=8$; $p<0.05$), private health care providers ($F=58.51$; $df=8$; $p<0.05$), dieticians/nutritionists ($F=82.65$; $df=8$; $p<0.05$) and supermarkets ($F=32.767$; $df=8$; $p<0.05$) to provide personalised nutrition. Participants in Ireland, Portugal and Greece formed a homogenous group of countries significantly more likely to advocate that personalised nutrition be delivered through the family doctors/GP. Those in Ireland, Portugal, Greece and Poland formed a homogenous group that were significantly less likely than other countries to advocate that personalised nutrition be delivered by private health organisations. Those in the Netherlands were significantly less likely than any other country to select the family Doctor/GP or private health providers. Those in Germany were less likely than other countries to advocate that personalised nutrition be delivered by a dietician/nutritionist. Participants in Ireland, Portugal, Greece and Poland were more likely than other countries to indicate that they preferred personalised nutrition to be delivered by a dietician/nutritionist. Compared to the other countries surveyed, participants in Norway were less likely, while those in Portugal were more likely, to want supermarkets involved in the delivery of personalised nutrition.

4. Discussion

This study is novel in having explored the distribution of perceived benefits, barriers, risks and trust in the various agencies to provide information on personalised nutrition between different EU countries with a view to determining how such issues could be addressed via policy. Previous research has suggested that greater perceived benefit is crucial

to the acceptance of personalised nutrition (Morin, 2009; Poínhos et al., 2014; Stewart-Knox et al., 2013; Su and Lu, 2012). In this regard, participants in the least economically stable EU countries (Greece, Poland, Ireland, Portugal and Spain), who rated the benefits of personalised nutrition higher than other countries, implied that enhanced potential and impact for personalised nutrition may exist in these countries. This begs the question of what an effective policy to promote personalised nutrition would look like. Perhaps economic subsidies could be considered in these more financially challenged countries (references?). Participants in the more affluent countries (the Netherlands, UK, Norway and Germany) rated the benefits of personalised nutrition to be significantly lower than other countries, which might imply some scepticism as to what personalised nutrition can deliver, and which may need to be addressed through a common policy for citizens to take up personalised nutrition in these countries. It is also possible that people in these countries may assume that the economic resources are available with which to treat illnesses. In the meantime policies could embed personalised nutrition within existing health promotion activities.

Participants in Spain rated the risks associated with personalised nutrition, and the barriers linked to data protection, higher than in any other country, suggesting that uptake of personalised nutrition in Spain may depend upon implementation of effective policies to protect data. Consistent with the results from the Lipgene survey (Stewart-Knox et al., 2009), which suggested relatively high perceived risks associated with personal information being used by insurers, employers and other authorities for citizens in Germany, Portugal and Poland, high perceived risks were associated with data protection in these countries in the current analysis. A previous survey conducted in Germany (Roosen et al., 2008) also indicated that perceived lack of data security could be a barrier to uptake of personalised nutrition. Together these findings suggest that for personalised nutrition to be taken up in Spain, Germany, Portugal and Poland, data protection policies need to be implemented, along with stringent regulations to protect personal data from being “sold on” or misused. The results of qualitative research in the Food4Me studies offered suggestions for regulatory

policy, including the prominent display of website logos, staff credentials and contact details (Fallaize et al., 2015; Stewart-Knox et al., 2013). There was also the suggestion that a guarantee of data protection be provided, and an assurance that personal and biomedical data would be stored separately. It is notable that participants in Norway, Ireland, Netherlands and UK provided significantly lower ratings than other countries for perceived risks and barriers to adoption of personalised nutrition associated with data protection. This might indicate that such issues would be less likely to deter uptake of personalised nutrition in these regions, or perhaps that greater adoption of internetbased health services has increased people's' willingness to provide personal data in relation to novel health-related applications.

It was previously reported that people anticipated problems in adhering to a prescribed diet in social situations (Stewart-Knox et al., 2013). The current analysis showed that barriers related to the social eating context were rated most highly by participants in Poland, suggesting that, in order to be able to comply with tailored diets, those in this region may require particular support in complying with a personalised eating plan in social situations, especially when eating outside the home. Technological advances such as those which enable personalised nutrition to be delivered (for example, ICT services, information and communications technology) also hold the potential to revolutionise how and where health is promoted (Wilson and Langford, 2014). Difficulties encountered in adhering to a personalised diet when outside of the home could be addressed by integrating the dietary health technology into society. Schools and workplaces are among just some of the institutions that could provide effective vehicles through which to deliver personalised eating plans and provide support. Food retailers and other commercial environments could also cater to needs associated with personalised diets.

Consistent with the preliminary qualitative studies (Fallaize et al., 2015), which indicated that larger, more „well known" private healthcare providers (such as BUPA) were more trusted than smaller, less well-known web providers, the results have suggested that participants in the UK have a relatively high degree of trust in government agencies to

provide information on personalised nutrition. This implies an imperative to involve the NHS when introducing personalised nutrition to the UK. Common European wide policy, meanwhile, should assist health professionals in obtaining training and provide support in the delivery of personalised nutrition services. There does, however, appear to be some hope for the future uptake of commercially delivered D-T-C services. Approximately 30% of those who responded to the Food4Me survey were willing to pay more for personalised than for non-personalised nutrition advice (Fischer et al., under review). Those willing to pay more tended to be male and on higher incomes suggesting a potentially lucrative niche market for commercial personalised nutrition service provision. That those participants in Spain, the Netherlands and Portugal indicated greater trust in commerce and the media to deliver personalised nutrition messages, suggests that commercial D-T-C ventures may be better received in these countries. Participants in the Netherlands, Greece and Poland reported relatively lower trust in government to provide information about personalised nutrition, which may imply a need for independent organisations with a commercial interest in delivering personalised nutrition D-T-C to be involved in the delivery of personalised nutrition within these countries. Discussants who took part in the prior qualitative studies (Fallaize et al., 2015; Stewart-Knox et al., 2013) suggested that government backing would serve to engender trust in commercial personalised nutrition schemes. This suggests a need for policies to be developed which could encourage public and private organisations to work in partnership, so that access to personalised nutrition can be as wide as possible. This also suggests that there is a need to explore further how the food industry (food producers, processors, retailers) could be encouraged to participate with government organisations through public/private partnerships in the delivery of personalised nutrition. Congruent with the notion of parallel or joint health service/commercially delivered services, the Food4Me survey indicated a strong preference for health service professionals to provide personal nutrition, with a substantial proportion endorsed private health care providers and supermarkets (figure 1). This corroborates the notion that personalised nutrition, to be

effective, should involve existing health care provision even where commercial companies are involved. That those in the less economically stable EU countries (Ireland, Portugal and Greece) were most likely to advocate that personalised nutrition be delivered through the family doctors/GP or a dietician/nutritionist implies a need for specific policies that encourage companies to collaborate with health systems in the delivery of personalised nutrition in these countries.

Insert figure 1 here

These data were derived from what appears to be the largest and widest scoping survey of attitudes to personalised dietary health intervention conducted to date. It was appropriate to conduct this survey on-line given that most available personalised nutrition services are delivered, at least in part, by means of internet technology (Ronteltap et al., 2012). The response rate for this study, although similar to that found by other online surveys (e.g. see Fan and Yan, 2010), could be considered low (31.9%). That the sample was quota sampled to be nationally representative, should have compensated for any bias inherent in the low response rate, as well as the high total number of responses. Questions and items can be assumed to have validity in having been derived from prior qualitative research conducted in all of the countries surveyed. Furthermore, the validity of the results is supported by the good internal consistency of the scales, despite these not having been subjected to previous psychometric testing. Another potential limitation associated with the survey is that because the notion of personalised nutrition is novel, the quality of response may have been affected by a lack of direct experience with the technology. Those who had volunteered to take part in the Food4Me proof of principle study appeared to be motivated differently to those the general population survey (Panzone et al., under review). Further enquiry of those who have experience of personalised nutrition, therefore, is needed.

Insert figure 2 here

5. Conclusion

The Food4Me project has sought to provide the European public with a voice in the development of policies directed toward the effective application of personalised nutrition, and to consider mechanisms through which to enhance the benefits and break down perceived barriers likely to be encountered in implementing personalised nutrition. The ultimate outcome will be to widen access to personalised nutrition, enhance public health and well-being, reduce health inequalities and reduce healthcare costs. Europeans possess shared health values and as such should be able to achieve common health-related objectives (EC, 2014). These findings in a nationally representative sample of EU citizens imply that a parallel, integrated, public-private delivery system would capture the needs of most potential consumers. The public would appear to be amenable to the concept of personalised nutrition and be aware of the potential benefits. These data, however, also provide evidence that different approaches may need to be taken in achieving objectives related to personalised nutrition in different EU countries (figure 2).

There is a requirement not only to personalise diets, but also to personalise the approach to the delivery of the intervention, taking into account cross-national differences in perceived benefits, barriers and preference for the delivery of personalised nutrition. Policies are required to reassure the public that personal data are protected. Agencies involved in the delivery of personalised nutrition need to be regulated so that they can be trusted to provide personal dietary information. Policies will be required to encourage societal institutions, both public and private, to facilitate people in reaping the benefits of prescribed diets outside the home environment and, in doing so, encourage acceptance of this novel health promoting technology.

More general measures will need to be put in place to raise awareness and encourage eventual uptake of personalised nutrition, and in keeping with current policies (EC., 2014;

Wilson and Langford, 2014), not only among the „worried wealthy" but most especially among the more „hard to reach" societal groups. The implications are that policies directed toward the removal of barriers, reduction of risk and promoting the benefits of personalised nutrition would encourage uptake of personalised nutritional services. Personalised nutrition speaks to both health and innovation policy and as such will need careful regulation, monitoring and coordination. This analysis, meanwhile, provides a basis upon which to place policies directed toward enabling initial attempts to roll out personalised nutrition to the general public, both as part of existing health provision and as a commercial enterprise.

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ITEM	FACTOR LOADING	FACTOR
I worry that a personalised diet plan is not effective	0.410	FACTOR 1 **DATA PROTECTION** **32% variance explained**
I worry about how my personal data might be used by authorities	0.881	
I worry that my personal data may not be treated confidentially	0.915	
I worry about how my personal data and test results might be stored	0.914	
I worry about how my personal data might be used by personalised nutrition providers	0.910	
I worry about how my personal data might be used by advertisers	0.888	
I worry about how my personal data might be used by insurance companies	0.874	
I worry that my personal data might be accessed by hackers	0.810	
Providing different foods for family members	0.598	FACTOR 2 **EATING CONTEXT** **23% variance explained**
Difficulties in maintaining healthy eating habits when eating out in restaurants	0.833	
Difficulties in maintaining healthy eating habits when eating at other people‟s houses	0.853	
Difficulties in maintaining diet when travelling	0.843	
Difficulties maintaining diet when at work	0.728	
Being told to eat foods you don‟t like	0.635	
Not being recommended to eat foods you like	0.636	
My family rejecting the adoption of personalised nutrition	0.786	FACTOR 3 **SOCIETAL** **13% variance explained**
My friends rejecting the adoption of personalised nutrition	0.891	
Society rejecting the adoption of personalised nutrition	0.864	

Table 2: Perceived risk/barriers to the uptake of personalised nutrition – factor structure

ITEM	FACTOR LOADING	FACTOR
Food retailers	0.803	FACTOR 1 **COMMERCE/MEDIA** **39% variance explained**
Food manufacturers	0.828	
Online personalised nutrition companies	0.723	
News media	0.734	
Social media	0.770	
Universities	0.725	FACTOR 2 **PROFESSIONALS** **13% variance explained**
Consumer organizations	0.724	
Dieticians/nutritionists	0.796	
Personal trainers	0.629	
Your family doctor	0.692	FACTOR 3 **GOVERNMENT** **8% variance explained**
Ministry or department of health	0.708	
The European Commission	0.556	
National Health provider	0.751	
Friends and family	0.817	FACTOR 4 **FRIENDS/FAMILY** **8% variance explained**

Table 3: Trust in agencies to provide information on personalised nutrition – factor structure

BENEFITS

ITEM	FACTOR LOADING	FACTOR
Knowing what foods are best	0.835	FACTOR **PERSONALISED NUTRITION BENEFITS** **67% variance explained**
Losing weight	0.691	
Gaining weight	0.261	
Fitness	0.891	
Improving family's health	0.900	
Improving health	0.939	
Improving quality of life	0.930	
Improving sports performance	0.766	
Preventing a future illness	0.906	
Preventing expression of hereditary illness	0.855	

Table 4: Perceived benefits of the uptake of personalised nutrition – factor structure

	Total means/SD	Norway means/SD	Germany means/SD	Spain means/SD	Greece means/SD	Poland means/SD	UK means/SD	Ireland means/SD	NL means/SD	Portugal means/SD
Is not effective	3.20 (0.93)	3.10 (0.92)	3.16 (0.99)	3.62 (0.92)	3.01 (0.88)	3.15 (0.93)	3.18 (0.91)	3.02 (0.90)	3.08 (0.87)	3.45 (0.84)
Used by authorities	3.43 (1.02)	3.14 (1.08)	3.60 (1.05)	3.55 (0.99)	3.57 (0.96)	3.57 (0.94)	3.33 (1.03)	3.30 (1.03)	3.35 (1.00)	3.45 (0.99)
Treated as confidential	3.51 (1.01)	3.23 (1.07)	3.62 (1.05)	3.69 (0.99)	3.63 (0.96)	3.60 (0.94)	3.41 (1.03)	3.39 (1.02)	3.38 (0.98)	3.61 (0.97)
Results may be stored	3.48 (1.00)	3.25 (1.06)	3.59 (1.04)	3.66 (0.98)	3.59 (0.96)	3.58 (0.92)	3.37 (1.02)	3.39 (1.01)	3.36 (0.98)	3.51 (0.93)
Used by PN providers	3.51 (0.99)	3.31 (1.06)	3.66 (1.01)	3.72 (0.95)	3.52 (0.93)	3.60 (0.91)	3.38 (1.00)	3.35 (1.00)	3.44 (0.99)	3.59 (0.93)
Used by advertisers	3.63 (1.01)	3.48 (1.09)	3.84 (1.04)	3.75 (0.98)	3.72 (0.96)	3.75 (0.93)	3.46 (1.03)	3.48 (1.05)	3.49 (1.00)	3.73 (0.94)
Used by insurance companies	3.67 (1.01)	3.57 (1.12)	3.80 (1.03)	3.76 (0.99)	3.76 (0.96)	3.74 (0.94)	3.53 (1.04)	3.56 (1.05)	3.49 (1.00)	3.76 (0.93)
Accessed by hackers	3.59 (1.05)	3.35 (1.10)	3.57 (1.10)	3.85 (1.02)	3.50 (1.06)	3.79 (0.98)	3.49 (1.04)	3.52 (1.05)	3.50 (1.01)	3.75 (0.99)

PN = Personalised Nutrition, the UK = the United Kingdom, NL = the Netherlands.
Statistical significance at $P<0.001$ was found on all perceived barriers.

Table 5a: Perceived barriers to the uptake of personalised nutrition (item means/SD) – DATA PROTECTION

	Total means/ SD	Norway means/SD	Germany means/SD	Spain means/ SD	Greece means/SD	Poland means/SD	UK means/SD	Ireland means/ SD	NL means/SD	Portugal means/SD
Different food for family members	3.71 (1.08)	3.65 (1.24)	3.70 (1.26)	3.66 (1.03)	3.86 (0.99)	3.84 (0.98)	3.70 (1.12)	3.75 (0.96)	3.57 (1.18)	3.65 (0.92)
Maintaining diet eating out	3.66 (1.06)	3.26 (1.25)	3.80 (1.14)	3.73 (1.05)	3.90 (0.91)	3.83 (1.04)	3.61 (1.05)	3.70 (0.98)	3.47 (1.10)	3.66 (0.90)
Maintaining diet at other houses	3.68 (1.02)	3.37 (1.16)	3.86 (1.11)	3.68 (0.99)	3.88 (0.91)	3.79 (0.99)	3.64 (1.04)	3.76 (0.95)	3.54 (1.07)	3.66 (0.84)
Maintaining diet while travelling	3.70 (1.04)	3.42 (1.17)	3.85 (1.12)	3.80 (0.99)	3.82 (0.96)	3.81 (0.99)	3.60 (1.07)	3.77 (0.98)	3.56 (1.10)	3.65 (0.87)
Maintaining diet at work	3.49 (1.15)	3.12 (1.27)	3.68 (1.24)	3.56 (1.09)	3.69 (1.05)	3.65 (1.09)	3.43 (1.21)	3.48 (1.10)	3.34 (1.18)	3.48 (0.97)
Being told to eat disliked food	3.61 (1.11)	3.18 (1.28)	3.87 (1.13)	3.45 (1.05)	3.85 (1.04)	3.77 (1.00)	3.61 (1.10)	3.65 (1.10)	3.52 (1.16)	3.57 (0.95)
Not being recommended liked food	3.57 (1.07)	3.22 (1.20)	3.82 (1.12)	3.53 (1.04)	3.68 (1.09)	3.69 (1.26)	3.56 (1.01)	3.58 (1.03)	3.56 (1.09)	3.46 (0.93)
Family rejecting PN	3.34 (1.19)	3.21 (1.30)	3.43 (1.30)	3.24 (1.09)	3.43 (1.14)	3.48 (1.24)	3.43 (1.18)	3.46 (1.11)	3.02 (1.29)	3.37 (1.02)
Friends rejecting PN	3.15 (1.21)	3.08 (1.27)	3.22 (1.30)	3.20 (1.12)	3.02 (1.23)	3.42 (1.19)	3.21 (1.23)	3.24 (1.13)	2.92 (1.28)	3.04 (1.10)
Society rejecting PN	3.31 (1.21)	3.08 (1.24)	3.15 (1.30)	3.19 (1.09)	2.86 (1.27)	3.44 (1.16)	3.15 (1.20)	3.15 (1.15)	2.93 (1.26)	2.93 (1.14)

PN = Personalised Nutrition, UK = United Kingdom, NL = the Netherlands.
Statistical significance at P<0.001 was found on all perceived barriers.

Table 5b: Perceived barriers to the uptake of personalised nutrition (item means/SD) – FAMILY/SOCIAL BARRIERS

	Total means /SD	Norway means/ SD	Germany means/SD	Spain means/ SD	Greece means/S D	Poland means/S D	UK means/ SD	Ireland means/ SD	NL means /SD	Portugal means/SD
Commerce/Media	12.71 (3.56)	12.17 (3.57)	12.68 (3.78)	13.28 (3.67)	11.66 (3.57)	12.56 (3.53)	12.69 (3.61)	12.69 (3.40)	13.16 (3.39)	13.41 (3.21)
Professionals	13.37 (2.64)	13.37 (2.67)	13.09 (3.14)	13.45 (2.69)	13.56 (2.65)	13.33 (2.75)	12.94 (2.55)	13.67 (2.38)	13.42 (2.53)	13.47 (2.31)
Government	13.12 (2.73)	12.90 (2.48)	13.50 (3.01)	13.82 (2.64)	12.64 (2.68)	12.65 (2.70)	13.32 (2.66)	13.44 (2.73)	12.57 (2.58)	13.22 (2.75)
Friends/Family	3.32 (0.85)	3.08 (0.79)	3.47 (0.95)	3.19 (0.87)	3.25 (0.89)	3.50 (0.80)	3.40 (0.87)	3.45 (0.82)	3.28 (0.75)	3.24 (0.76)

UK = United Kingdom, NL = the Netherlands.

Table 6: Trust in agencies to provide information on personalised nutrition (item means/SD)

	Total means/SD	Norway means/SD	Germany means/SD	Spain means/SD	Greece means/SD	Poland means/SD	UK means/SD	Ireland means/SD	NL means/SD	Portugal means/SD
What foods are best	3.11 (1.13)	2.69 (1.24)	3.04 (1.16)	3.39 (1.00)	3.51 (1.00)	3.31 (1.02)	2.77 (1.20)	3.29 (1.08)	2.65 (1.08)	3.32 (1.01)
Losing weight	2.97 (1.30)	2.67 (1.34)	2.90 (1.29)	3.17 (1.25)	3.37 (1.22)	3.18 (1.27)	2.73 (1.32)	3.18 (1.24)	2.51 (1.18)	3.05 (1.28)
Gaining weight	1.87 (1.15)	1.92 (1.16)	1.78 (1.10)	1.89 (1.16)	1.93 (1.19)	2.07 (1.22)	1.74 (1.08)	2.00 (1.22)	1.73 (1.03)	1.77 (1.11)
Fitness	3.19 (1.15)	2.79 (1.22)	2.96 (1.18)	3.35 (1.04)	3.81 (0.96)	3.44 (1.06)	2.77 (1.19)	3.37 (1.09)	2.80 (1.08)	3.39 (1.03)
Family's health	3.29 (1.20)	2.82 (1.26)	3.09 (1.21)	3.60 (1.02)	3.86 (1.00)	3.57 (1.09)	2.83 (1.27)	3.53 (1.10)	2.66 (1.12)	3.57 (1.04)
Health	3.41 (1.16)	3.02 (1.29)	3.23 (1.18)	3.70 (0.98)	3.96 (0.96)	3.61 (1.07)	2.99 (1.25)	3.62 (1.05)	2.87 (1.12)	3.64 (1.02)
Quality of life	3.38 (1.17)	3.00 (1.31)	3.24 (1.18)	3.68 (1.01)	3.89 (0.99)	3.48 (1.06)	3.00 (1.28)	3.60 (1.09)	2.83 (1.14)	3.64 (1.01)
Sports	2.83 (1.26)	2.29 (1.23)	2.92 (1.21)	3.12 (1.19)	3.37 (1.17)	2.86 (1.18)	2.34 (1.29)	2.86 (1.30)	2.48 (1.14)	3.19 (1.14)
Future illness	3.43 (1.21)	3.10 (1.31)	3.26 (1.23)	3.72 (1.06)	3.92 (1.03)	3.56 (1.10)	3.02 (1.30)	3.72 (1.11)	2.86 (1.19)	3.73 (1.10)
Hereditary illness	3.28 (1.28)	2.93 (1.34)	3.02 (1.31)	3.56 (1.15)	3.97 (1.07)	3.26 (1.21)	2.89 (1.35)	3.61 (1.16)	2.72 (1.23)	3.64 (1.12)

UK = United Kingdom, NL = the Netherlands.
Statistical significance at P<0.001 was found on all expected outcomes.

Table 7: Perceived benefit of personalised nutrition (item means/SD)

Figure 1: Preferences for the delivery of personalised nutrition

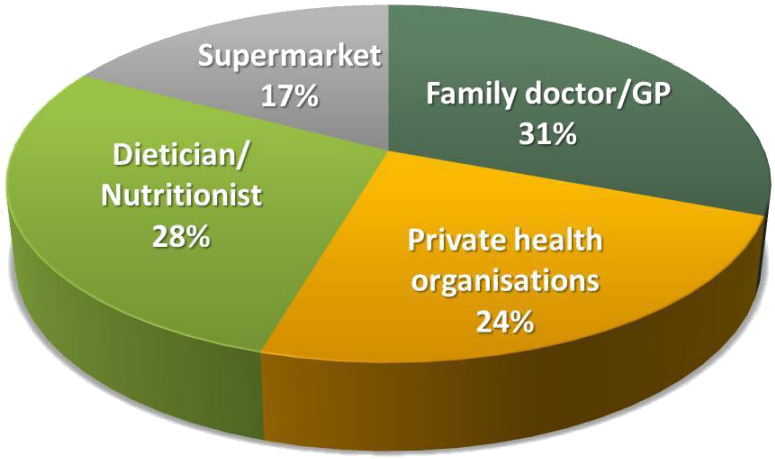
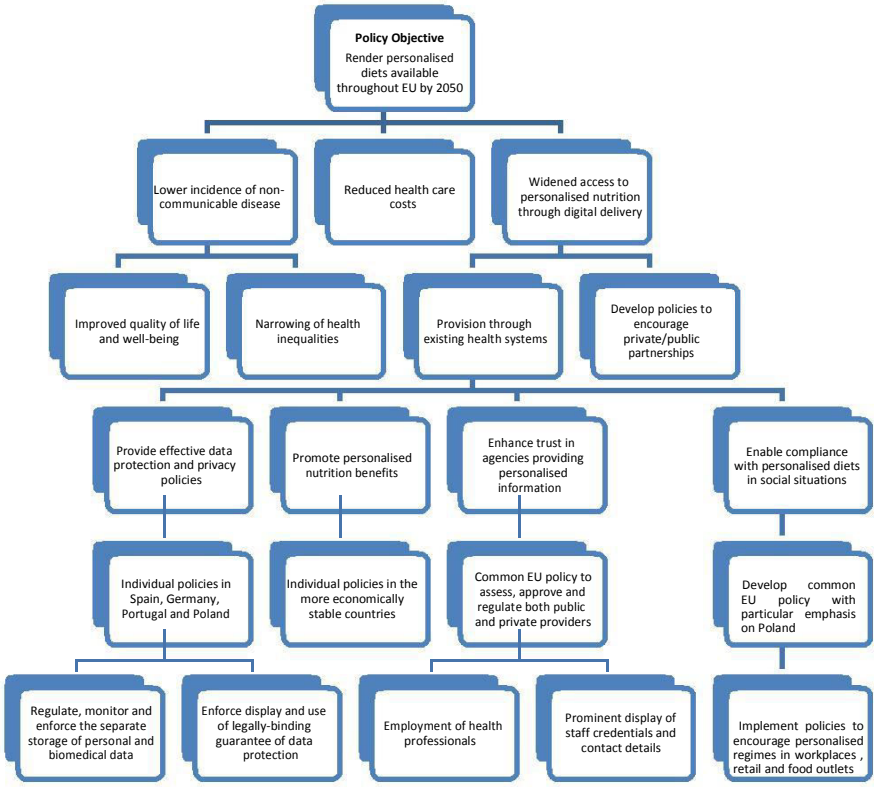


Figure 2: Policy map for the implementation of personalised nutrition in Europe



Table(s)

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Author / Year	Country	Sample size and characteristics	Study Design Methodology	Outcome measures	Key Findings and Policy Implications
Fallaize *et al.* 2015	UK and Ireland	N=73 Age: 18-65 yrs Gender: Mixed	Focus groups	Attitudes to PN* service delivery	Preference for services to be provided by government and delivered face to face. Payment was associated with increased commitment and motivation to comply with dietary recommendations. UK participants expected PN to be delivered free of charge on the NHS.
Poínhos *et al.* 2014	Europe 9 countries	N=9381 Quota sampled Age: Mixed Gender: Mixed	On-line survey	Intention to adopt PN	Benefit perception most important determinant of attitude towards adoption of PN. Nutrition self-efficacy a predictor of attitude and intention to take up PN. Perceived risk had a negative relationship with attitude and an inverse relationship with perceived benefit.
Berezowska *et al.* 2014	Europe 8 countries	N=124 Age: 18-65 yrs Gender: Mixed	Focus groups	Attitudes to PN services	Face to face interaction was deemed to reduce perceived risk and increase benefit. Qualified experts supported by scientific evidence increased value perception. Face-to-face support using lock-in strategies perceived as beneficial.
Stewart-Knox *et al.* 2013	Europe 9 countries	N = 126 Age: 18-65 and 30-65 yrs Gender: Mixed	Focus groups	Attitudes to PN	Positive attitudes towards PN. Benefit: control; anonymity. Concerns over data protection, service provider. Barriers: social; motivational.
Sanderson *et al.* 2013	USA (NY)	N=205 patients Age:18+yrs Gender: Mixed	Structured interviews	Determinants of uptake of genomics to treat diet related disease	Reasons for uptake: altruism; benefit to family members; personal health benefit; curiosity; and, understanding. Reasons for rejection: negative perception of research; not personally relevant; negative about procedures; practical barriers; and, fear of results.
Wendel *et al.* 201	Netherlands	N = 204 Age: Mean 38.3 yrs Gender: Mixed	Survey	Intention to receive/use PN	Usefulness of a system valued more and enjoyment valued less when a GP provided advice than if used out of their own curiosity. Trade-off between perceived risk and usefulness.
Pavlidis *et al.* 2012	Greece	N= 1504 Age: <35 yrs Gender: 51% female	Survey	Views on nutrigenomics	Majority thought that nutrigenomics should only be offered through health professionals not directly online. Concern about results being interpreted incorrectly.
Su & Lu, 2012	Taiwan	N = 258 Age: n/a Gender: 63% Male	Online survey	Acceptance/ preferences for nutrigenomics	Perceived benefit contributed to acceptance of PN. Hospital service provider preferred over direct sale and DIY
Morin, 2009	Canada consumers	N = 90 Age: n/a Gender: mixed	Focus groups – discourse analysis	Knowledge Attitudes to PN	Early diagnosis could lead to better diet and disease prevention. Concern that validity of tests was not established. Potential breach of privacy of concern.
Ronteltap *et al.* 2009	Netherlands	N=438 Age: 40-60 yrs Gender: Mixed	Evaluation of videos of PN scenarios	Perceptions and acceptance of PN	Public acceptance of PN is enhanced if perceived personal benefit, a supportive environment, and PN advice that can be easily incorporated into the daily routine. PN communication is preferred to be delivered by expert stakeholders.

Roosen *et al*. 2008	Germany	N=452 Age: n/a Gender: Mixed	Online survey	Attitudes to genetic profiling and PN	45% of the sample would agree to a genetic test to receive PN advice.

Brug *et al,* 1999	Various	8 studies	Literature review	Behaviour change theory (motivation, self-evaluation, agency)	Personalised dietary feedback more likely to be read, remembered and seen as personally relevant compared to standard materials. Tailored messages had greater motivating effects than non-tailored messages.

*PN= Personalised Nutrition

Table 1: Review of studies investigating the consumer view of personal nutrition